VDM Metals

VDM® Alloy 2120
Nicrofer 5821 hMoN

Material Data Sheet No. 4062
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VDM® Alloy 2120 MoN

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VDM® Alloy 2120 MoN is a nickel-chromium-molybdenum alloy with particularly low carbon content and an addition of nitrogen, developed by VDM Metals. The material distinguishes itself through an outstanding corrosion resistance under reducing as well as under oxidizing conditions. Furthermore, VDM® Alloy 2120 MoN is characterized by superior strength compared to other C alloys.

VDM® Alloy 2120 MoN is characterized by:

- extraordinary resistance against pitting and crevice corrosion as well as against chlorine induced stress corrosion cracking
- excellent resistance against a huge number of corrosive media, beginning with strong reducing conditions right up to oxidizing conditions
- excellent resistance against mineral acids like sulfuric acid, hydrochloric acid
- good ductility
- good weldability
- intended application area of -196 to 450 °C (-320 to 842 °F)

Designation

Standard	Material Designation
EN	2.4700
UNS	N06058

Standards

Product form	ASTM	VdTÜV
Strip	B 575	586
Rod and bar	B 574	
Sheet and plate	B 575	586
Tube and pipe welded	B 619 B 626	
Forging	B 564	

Table 1 – Designations and standards

Chemical composition

	Ni	Cr	Mo	Fe	Cu	Al	W	Co	Si	Mn	N	S	C	P
Min.		20.0	18.5								0.02			
Max.	bal.	23.0	21.0	1.5	0.5	0.4	0.3	0.3	0.1	0.50	0.15	0.01	0.01	0.015
Due to technical reasons this alloy may contain additional elements.														

Table 2 – Chemical composition (%)

Physical properties

Density	Melting range	Relative magnetic permeability at 20 °C (68 °F)
8,6 g/cm³ (537 lb/ft³) at 20 °C (68 °F)	1,330-1,370 °C (2,426-2,498 °F)	The material is non-magnetic

Temperature		Specific heat capacity		Thermal conductivity		Electrical resistivity	Modulus of elasticity		Coefficient of thermal expansion	
°C	°F	$\frac{J}{Kg \cdot K}$	$\frac{Btu}{lb \cdot °F}$	$\frac{W}{m \cdot K}$	$\frac{Btu \cdot in}{sq.\ ft \cdot h \cdot °F}$	µΩ · cm	GPa	10^6 psi	$\frac{10^{-6}}{K}$	$\frac{10^{-6}}{°F}$
50	122	406	0.097	9.8	5.66	124	-	-	11.4	6.36
100	212	436	0.104	11.1	6.41	125	200	29.0	11.6	6.42
200	392	457	0.109	13.0	7.51	125	194	28.1	12.2	6.76
300	572	471	0.112	15.5	8.67	126	188	27.3	12.5	6.96
400	752	482	0.115	16.9	9.76	127	182	26.4	12.9	7.17
500	932	487	o.116	18.5	10.7	129	177	25.7	13.2	7.32
600	1,112	546	0.130	21.8	12.6	130	169	24.5	13.8	7.64

Table 3 – Typical physical properties of VDM® Alloy 2120 MoN at elevated temperatures

Microstructural properties

VDM® Alloy 2120 MoN has a face-centered cubic structure. In the temperature range from 600 to 1,140 °C (1,112 to 2,084 °F), inter-metallic phases may form in the event of longer exposure times or too slow cooling down. In addition, carbides can precipitate on the grain boundaries, which reduce resistance against inter-crystalline corrosion.

Mechanical properties

The following mechanical properties are applicable to VDM® Alloy 2120 MoN in solution annealed form:

Temperature		**Yield strength $R_{p\,0.2}$**		**Yield strength $R_{p\,1,0}$**		**Tensile strength R_m**		**Elongation A**
°C	**°F**	**MPa**	**ksi**	**MPa**	**ksi**	**MPa**	**ksi**	**%**
20	68	360	52.2	400	58.0	760	110	40
400	762	200	29.1	240	34.8	560	81.2	40
500	932	180	26.1	220	31.9	530	76.9	40

Table 4 – Mechanical short-term properties of the soft annealed VDM® Alloy 2120 MoN at room temperature and elevated temperatures (min. values)

ISO V-notch impact energy

Average value, room temperature: ≥ 185 J

Average value, -196 °C (-320.8 °F): ≥ 140 J

Cut axis perpendicular to the surface

1) average value from 3 samples. The minimum average value may only be fallen below by a single value, namely no more than 30 %.

2) These values only apply for normal samples according to DIN EN ISO 148-1. For undersized samples according to DIN EN ISO 148-1, the minimum values indicated for the notch impact energy linear to the sample cross-section in the gap must be reduced. For undersized samples < 5 mm according to DIN EN ISO 148-1, the values for the individual case must be agreed separately with the manufacturer.

Corrosion resistance

VDM® Alloy 2120 MoN can be used in many chemical processes with both oxidizing as well as reducing media. The high chromium and molybdenum concentrations make the alloy very resistant to chloride attacks. VDM® Alloy 2120 MoN has a PREN no. of 86 (PREN = %Cr+3.3Mo+30N). In general, the material is superior to other C-alloys in terms of crevice and pitting corrosion (see Figure 1).

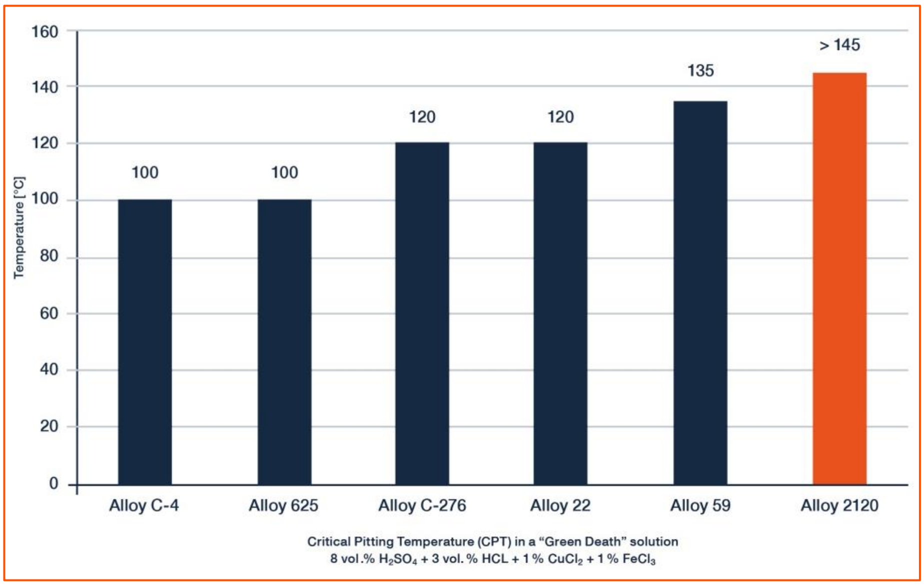

Figure 1 – Critical pitting temperature in a "green death" solution"

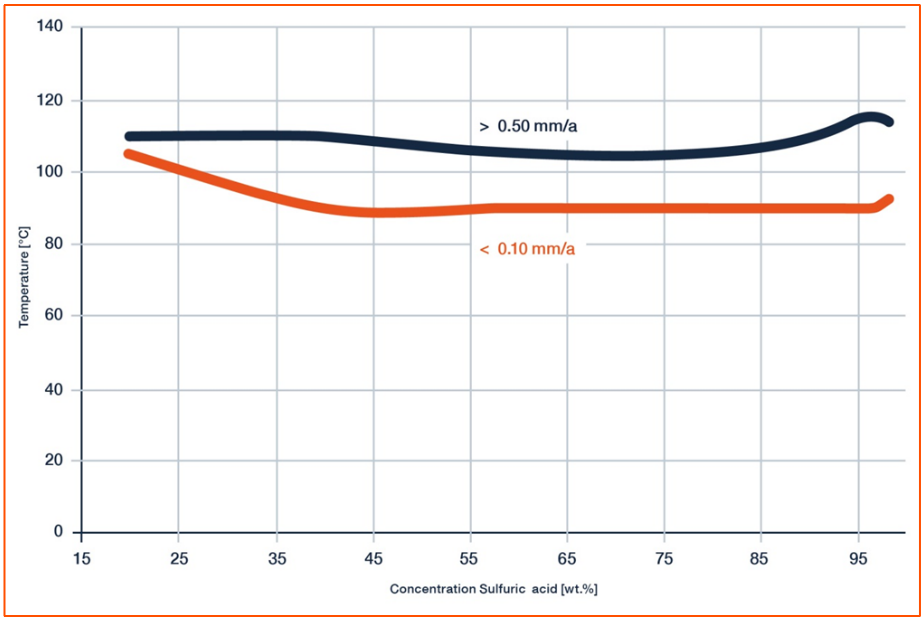

Figure 2 – ISO corrosion diagram of VDM® Alloy 2120 MoN

The material possesses outstanding corrosion resistance in reducing acids, such as hydrochloric acid and sulfuric acid (see Figure 2). VDM® Alloy 2120 MoN exhibits a good resistance to inter crystalline corrosion according to ASTM G28 method A. Optimum corrosion resistance is only ensured if the material is used in a clean and metallic bright condition.

Applications

VDM® Alloy 2120 MoN has a wide range of applications in the chemical, petrochemical and pharmaceutical industries as well as in energy production and environmental technologies.

Typical applications include:

- components in flue gas desulfurization and waste incineration plants as e.g. scrubbers, raw gas inlets and heat recovery systems
- handling of mineral acids like sulfuric acid, hydrochloric acid and acid mixtures even when contaminated with chlorides
- acetic acid and acetic anhydride production
- production and processing of halogen containing chemicals
- equipment for organic synthesizes and fine and specialty chemicals production
- components exposed to seawater and to highly concentrated brines
- sour gas and geothermal services

Fabrication and heat treatment

VDM® Alloy 2120 MoN can readily be hot and cold worked and machined.

Heating

Workpieces must be clean and free from all kinds of contaminants before and during any heat treatment. VDM® Alloy 2120 MoN may become impaired if heated in the presence of contaminants such as sulfur, phosphorus, lead and other low-melting-point metals. Sources of such contaminants include marking and temperature-indicating paints and crayons, lubricating grease and fluids and fuels. Fuels must be as low in sulfur as possible. Natural gas should contain less than 0.1 wt.-% sulfur. Fuel oils with a sulfur Content not exceeding 0.5 wt.-% are suitable. Due to their close control of temperature and freedom from contamination, thermal treatments in electric furnaces under vacuum or an inert gas atmosphere are to be preferred. Treatments in an air atmosphere and alternatively in gas-fired furnaces are acceptable though, if contaminants are at low levels so that a neutral or slightly oxidizing furnace atmosphere is attained. A furnace atmosphere fluctuating between oxidizing and reducing must be avoided as well as direct flame impingement on the metal.

Hot forming

VDM® Alloy 2120 can be hot-formed at a temperature range of between 1,200 and 1,050 °C (2,190 and 1,922 °F) with subsequent rapid cooling down in water or in air. For heating up, workpieces should be placed in a furnace that has been heated up to the maximum hot-forming temperature (solution annealing temperature). The workpieces should be retained in the furnace for around 60 minutes per 100 mm of thickness once the furnace has reached its temperature again. After this, they should be removed from the furnace immediately and formed within the temperature range stated above, with reheating necessary once the temperature reaches 1,050 °C (1,922 °F). Solution annealing after hot forming is recommended for the achievement of optimal properties and maximum corrosion resistance.

Cold forming

For cold forming the material should be in the annealed condition. VDM® Alloy 2120 MoN has a higher work-hardening rather than austenitic stainless steels. This should be taken into account when selecting forming equipment. Interstage annealing may be necessary with high degrees of cold forming. After cold working with more than 15% deformation solution annealing is required before use.

Heat treatment

Solution annealing should take place at temperatures of between 1,150 and 1,185 °C (2,102 – 2,156 °F) to achieve optimal properties. The retention time during annealing depends on the semi-finished product thickness and can be calculated as follows:

- For thicknesses d ≤ 10 mm (0.4 in), the retention time is t = d • 3 min/mm
- For thicknesses d = 10 to 20 mm (0.4 to 0.8 in), the retention time is t = 30 min + (d - 10 mm) • 2 min/mm
- For thicknesses of d > 20 mm (0.8 in), the retention time is t = 50 min + (d - 20 mm) • 1 min/mm

The retention time commences with material temperature equalization; longer times are generally considerably less critical than retention times that are too short. For maximum corrosion resistance, the workpieces must be quickly cooled from the annealing temperature of at least 1,100 to 500 °C (2,012 to 932 °F) with a cooling rate of >150 °C/min (302 °F). The material must be placed in a furnace that has been heated up to the maximum annealing temperature before any heat treatment. The cleanliness requirements listed under "Heating" must be observed. For strip product form, the heat treatment can be performed in a continuous furnace at a speed and temperature that is adapted to the strip thickness.

Descaling and pickling

Oxides of VDM® Alloy 2120 MoN and discoloration adjacent to welds are more adherent than on stainless steels. Grinding with very fine abrasive belts or discs is recommended. Care should be taken to prevent tarnishing. Before pickling which may be performed in a nitric/hydrofluoric acid mixture with proper control of pickling time and temperature, the surface oxide layer must be broken up by abrasive blasting, by carefully performed grinding or by pretreatment in a fused salt bath.

Machining

Machining of VDM® Alloy 2120 should take place in an annealed condition. Because of the considerably elevated tendency toward work hardening in comparison with low-alloy austenitic stainless steels, a low cutting speed and a feed level that is not too high should be selected and the cutting tool should be engaged at all times. An adequate chip depth is important in order to cut below the previously formed strain-hardened zone. Optimum heat dissipation through the use of large quantities of suitable, preferably aqueous, lubricants has considerable influence on a stable machining process.

Welding Information

When welding nickel alloys and special stainless steels, the following information should be taken into account:

Safety
The safety recommendations of the manufacturer of welding consumables have to be taken into consideration especially to avoid dust and smoke exposure.

Workplace
A workplace, which is specifically separated from areas in which C-steel is being processed, must be provided. Maximum cleanliness is required, and drafts should be avoided during gas-shielded welding.

Auxiliary equipment and clothing
Clean fine leather gloves and clean working clothes must be used.

Tools and machines
Tools that have been used for other materials may not be used for nickel alloys and stainless steels. Only stainless steel brushes may be used. Machines such as shears, punches or rollers must be fitted (e.g. with felt, cardboard, films) so that the workpiece surfaces cannot be damaged by such equipment due to pressed-in iron particles as this can lead to corrosion.

Edge preparation
Welding edge preparation should preferably be carried out using mechanical methods such as lathing, milling or planing. Abrasive waterjet cutting or plasma cutting is also possible. In the latter case, however, the cut edge (seam flank) must be cleanly reworked. Careful grinding without overheating is also permissible.

Striking the arc
Striking may only take place in the seam area, such as on the weld edges or on an outlet piece, and not on the component surface. Striking points are places that may be more susceptible to corrosion.

Included angle
Compared to C-steels, nickel alloys and special stainless steels exhibit lower heat conductivity and greater heat expansion. Larger root gaps and web spacing (1 to 3 mm/ 0,039 to 0,118 in) are required to live up to these properties. Due to the viscosity of the welding material (compared to standard austenitic steels) and the tendency to shrink, opening angles of 60 to 70° – as shown in Figure 3 – have to be provided for butt welds.

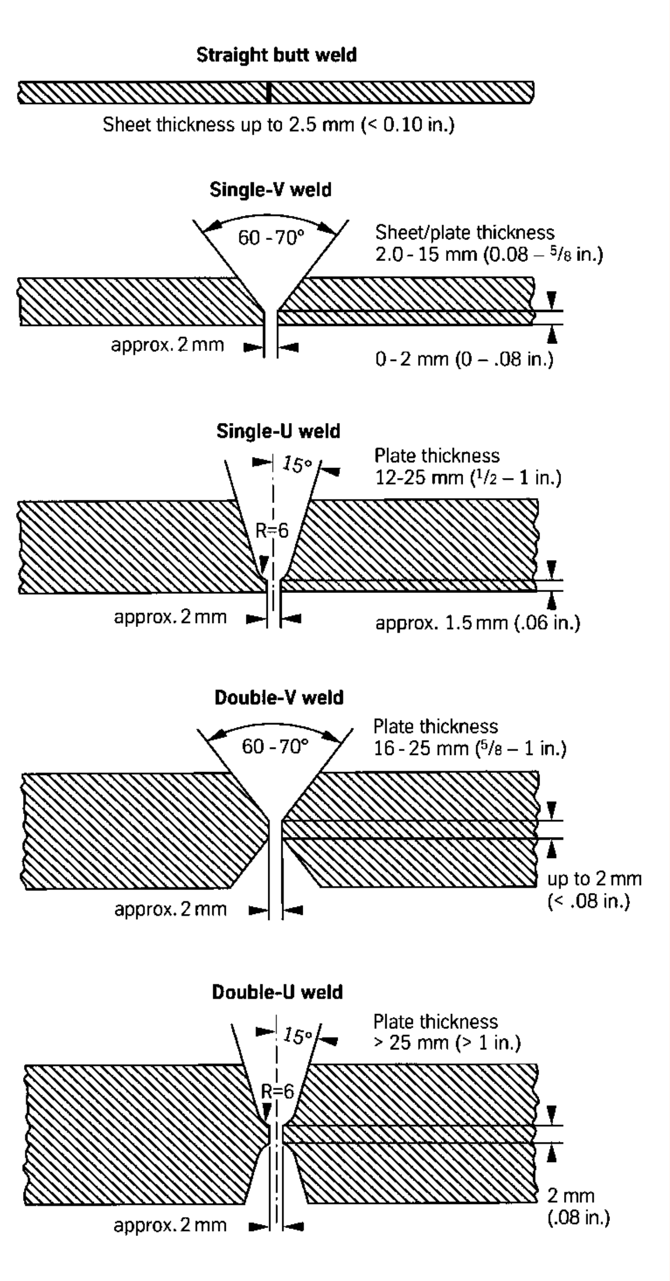

Figure 3 – Seam preparation for welding nickel alloys and special stainless steels

Cleaning

Cleaning of the base material in the seam area (both sides) and the welding filler (e.g. welding rod) should be carried out using acetone.

Welding parameter and influences

Care should be taken that the work is performed with a deliberately chosen, low heat input as indicated in Table 6 by way of example. The stringer bead technique is recommended. The interpass temperature should not exceed 150 °C (302 °F). The welding parameters should be monitored as a matter of principle.

The heat input Q can be calculated as follows:

$$Q = \frac{U \cdot I \cdot 60}{v \cdot 1.000} \left(\frac{kJ}{cm}\right)$$

U = arc voltage, volts
I = welding current strength, amperes
v = welding speed, cm/minute

Post- treatment (brushing, pickling and thermal treatments)

Brushing with a stainless steel wire brush immediately after welding, i.e. while the metal is still warm generally results in removal of heat tint and produces the desired surface condition without additional pickling.

Pickling, if required or pre-scribed, however, would generally be the last operation performed on the weldment. Please also refer to the information on ‘Descaling and pickling. Neither pre- nor post weld heat treatments are normally required.

Following filler metals are recommended
VDM® FM 2120
ISO 18274 - S Ni 6058 (NiCr21Mo20),
AWS 5.14 Classification ERNiCrMo-19 (UNS N06058)
as TIG rods, weld wire, wire electrode
(TÜV data sheet No. 18953, 18954, 18965)

Thick-ness	Welding process	Filler material		Root pass1)		Internediate and final passes		Welding speed	Shielding gas	
mm (in)		Diameter mm (in)	Speed (m/min.)	I in (A)	U in (V)	I in (A)	U in (V)	(cm/min.)	Type	Rate (l/min.)
3 (0.118)	m-TIG	1.6-2 (0.063-0.079)	-	90	10	110-120	11	15	I1	8-10
6 (0.236)	m-TIG	2.0 (0.079)	-	100-110	10	120-140	12	14-16	I1	8-10
8 (0.315)	m-TIG	2.4 (0.0945)	-	100-110	11	130-140	12	14-16	I1	8-10
10 (0.394)	m-TIG	2.4-3.2 (0.063-0.079)		100-110	11	130-140	12	14-16	I1	8-10
3 (0.118)	v-TIG 2)	1.0-1.2 (0.039-0.0472)	1.2	-	-	150	11	25	I1	12-14
5 (0.197)	v-TIG 2)	1.2 (0.0472)	1.4	-	-	180	12	25	I1	12-14
8 (0.351)	MIG/MAG3)	1.0-1.2 (0.039-0.0472	6-7	-	-	130-140	23-27	24-30	I1	18
10 (0.394)	MIG/MAG3)	1.2 (0.0472)	6-7	-	-	130-150	23-27	25 - 30	I1	18

1) Root layer: For all weld processes, a sufficient protection with backing gas e.g. by Ar 4.6 is needed

2) Automated TIG: If applicable, the root layer should be welded manually.

3) For MAG welding: The application of a 3 or 4 component gas mix is recommended (CO2 < 0.12%).
Z-ArHeHC30/2/0,05, Z-ArHeHC30/2/0,12

Section energy kJ/cm: TIG, MIG/MAG manual or automated ca. 8.

The parameters given are indicative values to facilitate the setting of the welding machine.

Table 5 – Welding parameters

Availability

VDM® Alloy 2120 MoN is available as plate, sheet, strip and wire.

Plate/sheet

Delivery condition: hot or cold-rolled, heat-treated, de-scaled or pickled

Condition	**Thickness mm (in)**	**Width mm (in)**	**Length mm (in)**
Cold rolled	1-7 (0.039-0.275)	≤ 2,500 (98.42)	≤ 8,000 (314.96)
Hot rolled*	3-30 (0.11-1.18)	≤ 2,500 (98.42)	≤ 8,000 (314.26)

* Plates/ sheets ≤ 2 mm (0.08 in) thickness are available on request.

Strip

Delivery condition: cold-rolled, heat-treated, pickled or bright annealed

Thickness mm (in)	**Width mm (in)**	**Coil-inside diameter mm (in)**			
0,025-0,15 (0.000984-0.00591)	4-230 (0.157-9.06)	300 (11.8)	400 (15.7)	500 (19.7)	–
0,15-0,25 (0.00591-0.00984)	4-720 (0.157-28.3)	300 (11.8)	400 (15.7)	500 (19.7)	–
0,25-0,6 (0.00984-0.0236)	6-750 (0.236-29.5)	–	400 (15.7)	500 (19.7)	600 (23.6)
0,6-1 (0.0236 -0.0394)	8-750 (0.315-29.5)	–	400 (15.7)	500 (19.7)	600 (23.6)
1-2 (0.0394-0.0787)	15-750 (0.591-29.5)	–	400 (15.7)	500 (19.7)	600 (23.6)
2-3 (0.0787-0.118)	25-750 (0.984-29.5)	–	400 (15.7)	500 (19.7)	600 (23.6)

Rolled sheet – separated from the coil – are available in lengths from 250-4,000 mm (9.84 to 157.48 in).

Wire

Delivery condition: drawn bright, ¼ hard to hard, bright annealed in rings, containers, on spools and headstocks

Drawn mm (in)	**Hot rolled mm (in)**
0.16-10 (0.006-0.04)	5.5-19 (0.22-0.75)

Rod and bar

Delivery condition: forged, rolled, drawn, heat-treated, oxidized, de-scaled or pickled, twisted, peeled, ground or polished

Dimensions	**Outside diameter mm (in)**	**Length mm (in)**
General	6-800 (0.236-31.5)	1,500-12,000 (59.1 – 472)

Other dimensions and shapes such as circular blanks, rings, seamless or longitudinal-welded tubes and pipes or forgings are subject to special enquiry.

Technical publications

H. Alves; R. Behrens; D. Kurumlu; R. Bäßler: High Performance Alloys to mitigate Corrosion in the Energy Industry – A Contribution to a clean Environment, Eurocorr 2013, Estoril Portugal

H. Alves; D. Kurumlu; R. Behrens: A New Developed Ni-Cr-Mo Alloy with Improved Corrosion Resistance in Flue Gas Desulfurization and Chemical Process Applications, Corrosion 2013, Paper N° 2325, NACE international, Orlando, Florida 2013

H. Alves; R. Behrens; L. Paul: Evolution of Nickel Base Alloys – Modification to Traditional Alloy for Specific Applications, Corrosion 2014, Paper N° 4317, NACE international, Houston, Texas 2014

H. Alves; R. Behrens; L. Paul: Recent Experiences and Applications with a New Ni-Cr-Mo-N Alloy, Corrosion 2015, Paper N° 5683, NACE international, Dallas Texas 2015

Legal Notice

18 May 2017

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